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VISITING THE SOLAR FAMILY

Y. Golovanov

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16. Abstract Background of Soviet and American "firsts" in space and sketch of scope and history of JPL are presented, followed by 5 sections -- on Mariner-9 and its results, the question of possible life on Mars, the aborted Voyager, planned Viking and possible joint international manned Mars missions, the Soviet and U.S. Venus missions completed and Mariner-10 Venus Mercury flight, and the Pioneer-10 and -11 Jupiter-Saturn-deep space flights. A brief epilogue refers to the anodized gold "letter to the stars" attached to Pioneer-10.			
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ANNOTATION

"Novvy Mir" ("New World") is a fifty-year-old literary-artistic, sociopolitical monthly with a circulation of 175,000. Therefore, this 21-page essay by Yaroslav Golovanov is intended for the widest circles of Soviet readers. It is devoted to his mid-1973 visit to the Jet Propulsion Laboratory (Pasadena), to which he refers as the main enterprise for planning and carrying out all American unmanned spaceflights, and lately, in particular, all flights of planetary probes. He deals with the "recent, present, and future works of this scientific center," but describes it as not an analysis, but only a review of what he had seen and learned. In glowing and enthusiastic terms, he describes not only the scientists and spacecraft, but also mysteries of the planets, efforts at solving them, and future flights.

VISITING THE SOLAR FAMILY

Y. Goiovanov

I believe in the brilliant future of mankind. I believe that mankind not only inherits the earth, but is transforming the world of the planets . . .

-- K. E. Tsiolkovskiy

During the summer of last year, together with a small group of Soviet journalists, I happened to make a trip to the scientific centers of the U.S.A. The program of this trip was extensive and diverse. We met physicists and radio engineers, chemists and physicians, pharmacists and astronomers. Personal sympathies, special training and many years of experience in journalistic work made me most interested in the achievements of the Americans in the field of space research. We visited the Manned Space Flight Center in Houston, where we became acquainted with details of the work of the Skylab space station, and we became acquainted with preparations of the joint Soviet-American Soyuz-Apollo flight. /200*

Another interesting "space" point on our trip was the famous California Institute of Technology, more precisely, its Jet Propulsion Laboratory. Speaking in the language of our industrial workers, this is the leading enterprise in planning and accomplishing all American unmanned space flights, recently, principally flights of various unmanned spacecraft to the planets of the solar system. I wish to tell of the recent, present and future work of this scientific center.

I wish to tell it, because far less is known of it than of the flights of the American astronauts. On the whole, this is understandable and explainable: The fact itself of a flight of man in space makes this flight interesting, since the man himself and his life and work in space, so foreign to all life, is interesting. Any, even the most modest man, knowing nothing of flight beyond the earth, continually imagines himself in the place of the astronaut, sets up the invisible examination himself: If this were I, I could, but this is scarcely . . . More briefly, any manned spaceflight is popular, because it is animated. I repeat, this is explainable, but it is somehow wrong. So much for that.

*Numbers in the margin indicate pagination in the foreign text.

Of course, it would be naive to expect that the launch of even the most perfect, "intelligent" and expensive unmanned spacecraft would cause the same emotions in people as a flight of astronauts. More frankly, great delight in strictly perfect technology is a rare gift of rare specialists. No, the unfairness of which I speak is not this. According to the accurate remark the outstanding American astrophysicist, James Van Allen, a minimum of 80% of the scientific results of space research and almost all the results of practical application of space technology have resulted, thanks to the least famous spacecraft.

I agree with Doctor Van Allen: hard-working unmanned spacecraft are actually covered with glory. The popularity of the Soviet lunakhod is rather the exception than the rule in the long list of them. But then, remember: The lunakhods moved, went forward, backward, examining the lunar mountains and valleys with their television eyes; they were "alive," and, to some extent, also were animated, /201 and there was excitement over them, as if they were "alive": "How are they? Are they well? They have not fallen into a crater? Have they fed their solar batteries? Have they gone further? . . ."

Meanwhile, many flights of unmanned spacecraft have marked major stages in space research and some of them have become, in the full sense of this word, epochal events in astronautics, yes, if you please, in all of modern natural science.

In these notes, I would not wish to make comparisons and draw parallels between what we have seen in California and similar work at home. It is hardly necessary to prove that we and the Americans have much to be proud of in this field. It is enough to recall only such Soviet unmanned spacecraft as Luna-2, which was first to reach another celestial body, Luna-3, the first to photograph the hitherto invisible "backside" of the moon, Luna-9, the first to complete a soft landing on the moon and the "panorama of the century" transmitted from there, a photograph of the lunar surface, Luna-10, the first artificial satellite of the moon, Luna-16 and Luna-20, the first to return samples of lunar soil, collected by automatic machines, to the earth and Venera-4 and Mars-3, the first messengers of earth to the surfaces of neighboring planets.

Together with this, the flights of such American unmanned spacecraft as Surveyor-3 gave outstanding results; it was the first to study the structure of the lunar soil, by cutting a small furrow with a tiny scoop; Mariner-2 -- it obtained the first data about Venus from a flyby course; Mariner-4 -- it transmitted the first 22 photos of Mars, made from a distance of about 10,000 kilometers, to earth; Mariner-9, Mariner-10 and Pioneer-10 -- I tell of them in these notes.

Soviet scientists and designers follow the work of their colleagues across the ocean with great attention. At the same time, American specialists always give their due to Soviet studies of the planets of the solar system.

True, for the sake of accuracy, it must be said that, during the years of the "cold war," when the term "space race" arose in the U.S.A., there were people, who attempted to introduce discord in the healthy atmosphere of scientific compacts.

For example, on the celebration honoring the 10th anniversary of the launch of the first American earth satellite, at the Washington National Press Club, Werner von Braun, then director of the George Marshall Space Flight Center, said with alarm:

"There is a dangerous similarity between the present situation and the state of affairs in the 1950's. In contrast to five American interplanetary launches, the USSR has launched from 15 to 20 spacecraft into interplanetary space, and has recently demonstrated great capabilities in the field of interplanetary research. (He had in mind our Venera-4 spacecraft.) I would not be very much surprised, if the first soft landing on Mars were accomplished by Soviet spacecraft. In this case, the U.S.A. will once again be deprived of a historic scientific priority," Von Braun threatened.

Braun frequently took upon himself the unseemly role of cracking the whip, urging American astronautics forward in its race to the stars.

However, by no means all of the specialists across the ocean were so jealous when Braun's prediction occurred: The first soft landing on Mars actually was accomplished by the Soviet interplanetary spacecraft Mars-3, on 2 December 1971, at 16 hours 47 minutes Moscow time. "The Soviet sickle-and-hammer flag rests on the surface of Mars" reported UPI. "This is the first object made by the hand of man, which was sent to the planet, during the course of Soviet-American research on Mars. Mars-3 marked the long-expected triumph of the Soviet Mars program." American investigators, including Doctor Pickering, sincerely congratulated their Soviet colleagues and, in these congratulations, the words were not of rivalry, but of mutual cooperation, the only reasonable way toward solution of such a grandiose problem as study of the nature of the solar system.

Each country has gone and is going its own way, working out its traditional methods of research, responding to its concepts of the future of space research and the science of mankind overall. I repeat, it is difficult to compare, useless for sure and, most likely, /202 harmful. My purpose is far more modest. It is not analysis, but only information on what we saw and learned in Pasadena, the very nest in which flights of all these Rangers and Surveyors, Mariners and Pioneers became fully fledged and from where they flew off on their long flights.

Pasadena is a very small city on the outskirts of Los Angeles, more accurately, a part of this tremendous, excessively widely

sprawled city. In 1936, when Dr. Theodore von Kármán began to test his almost toy rockets, flying on alcohol and oxygen, here, Los Angeles was still remote and the whistling of their engines interfered with no one. Years passed, the city grew and the rockets of Pasadena grew along with it. The California Institute of Technology is rightfully proud of the fact that it was the first scientific center of the U.S.A., which was seriously occupied with rocket technology. Test stands were built in the mountains near Pasadena, on which tests of the first American rocket accelerators for aircraft were tested during the years of World War II.¹

Beginning in 1944, after the official opening of the Jet Propulsion Laboratory, its main work was performed on the order of the military service. The Sergeant and Corporal military rockets and the Private antiaircraft rocket were born in Pasadena. Design of the first American artificial earth satellite, Explorer-1, began here in 1957.² We saw an accurate copy of this satellite in a glass box, in the main hall of the museum; it is a multisided pyramid, similar to a short, sharply pointed stub of a huge pencil. This "pencil" wrote the first line in the annals of American astronautics.

After launch of the Explorer and formation of the National Aeronautics and Space Administration (NASA) in 1958, the laboratory in Pasadena switched more and more rapidly from military subjects to space. From year to year, the California Institute of Technology, the main forge of engineering personnel in the western U.S.A., has been doing its more and more weighty bit in executing the space programs of the United States.

On the other hand, this has been more the rule than the exception for American universities. In 1967, the universities developed about 1400 projects in 30 NASA programs. From 1958 through 1967, NASA spent \$572 million in support of space research in institutions of higher learning. University scientists produced 64% of all publications on space during this time. The Jet Propulsion Laboratory formally belongs to the Institute now. However, as the saying goes, who pays the money calls the tune: Almost all the subjects of the Laboratory are determined by NASA.

The name of the Laboratory sounds quite arbitrary today. For a long time, they have been occupied here with, not only jet engines and not even so much jet engines, as electronics, radiocommunications, control processes and means of orientation of objects in space. While,

¹The first work in this field was carried out in 1927-1932, at the Leningrad Gas Dynamics Laboratory.

²Explorer-1, weighing 8.3 kilograms, was launched into orbit 1 February 1958, almost four months after the launch of the first-in-the-world Soviet artificial earth satellite, weighing 83.6 kilograms.

in general, quite recently, at the word "laboratory," the image arose most often of a room, equipped with flasks and retorts, in which eccentrics in white jackets sat, clinging to microscopes, the California Laboratory is not a room, and not rooms, and not a building, but a whole scientific city: several dozen buildings, in which about 4,000 "laboratory workers" work, connected most closely to dozens of other scientific research centers, astronomical observatories, rocket launching fields in California and Florida, and control stations in the U.S.A., Spain, Australia and South Africa.

There is a nice city for you, with green lawns, accurately trimmed grass and spacious automobile parking lots, which we saw in the hot California mid-day, when, after long disputes in the hotel, as to whether or not to put on neckties in such hot weather, we crossed the threshold of the Laboratory in Pasadena, greeting a very courteous and inquisitive gentleman, in a shiny civilian suit with square passes, with whom we became acquainted shortly together with his family, the host.

1

The man was so involved with his affairs that, initially, he did not pay us any attention. Continuing to hum some piece under his breath, he looked through a pack of tiny cards and, every minute, he turned to a large globe, more than a meter in diameter, spreading out his secret game of solitaire on its steep-sided white surface. Did he know that, at these moments, he was a fortune-teller, predicting the future of the most incredible and probably the most romantic journeys, which have been destined to take place in the 20th century? However, this was not play, but actual photomaps, placed on the globe in the most fantastic mosaic of deserts, canyons and craters. 203

Thus, the first Martian globe literally grew before our eyes. I looked at this large globe, in which fewer and fewer white spots remained, in the direct and figuratively senses, and I thought that, many years from now, my grandchildren would not believe stories of this first Martian globe and will not believe that grandfather knew Gagarin, because Gagarin will be a legend and the globe, a textbook, just as familiar to them as the globe of the earth. And I thought again, looking at this globe, of what a tremendous amount of work, devices and inventiveness were expended, what tense moments of expectation and doubt were survived, only in order to know where each mountain stands on a strange, remote planet, where each ravine cuts across it and in which the indomitable, violent human thirst for knowledge was delighted and excited again each time.

The globe in Pasadena was brought back by Mariner-9, probably the most popular unmanned spacecraft of all the American unmanned spacecraft. If you ask an American who more or less follows space research (and this is far from every American!) which, in his opinion, is the greatest achievement of American astronautics overall, he is almost sure to reply: the landing on the moon and photographs of Mars obtained by Mariner-9.

Dr. William Pickering, who has already headed the Jet Propulsion Laboratory for 20 years, gave us a package of large photographs, the most interesting of those which were glued to the globe. The name of this man, one of the pioneers in mastery of space, is well known to Soviet specialists and to all who are interested in astronautics. Under his leadership, the American programs of study of the Moon, Venus and Mars has been accomplished. The American mooncraft, the Rangers and Surveyors, were planned in his Laboratory. He inspired the creation of the Mariner general-purpose interplanetary laboratories, two of which flew to Venus and four to Mars. The last Mariner, No. 10, has flown around two planets, Venus and Mercury, which we shall mention later. Thus, here Doctor Pickering has given us a package of Mars photographs, and Doctor Murray kindly agreed to comment on them.

Bruce Murray, a young man, more like an athlete than a professor of astronomy, met us in his office, painted with bright children's figures. This is one of the leading planetologists of the U.S.A., the author of numerous works on Mars, including popular ones. The latest book, Mars and Human Intelligence, which was published after our return to Moscow, was written by Murray, in collaboration with the well-known astronomer, Carl Sagan, journalist Walter Sullivan and the famous American science-fiction writers Arthur Clarke and Ray Bradbury. It is an intermittent, endless digression of witty dialogue, in which the scientists turn loose their imaginations, and the writers attempt to give scientific predictions. Murray took an active part in interpreting the Mariner Mars photos, and directed the photography experiments aboard Mariner-10, and it was evident that it was a pleasure for him to speak of them.

(I note parenthetically that, if there is something for an American to be proud of, as in this case, they are proud of it with a certain childish frankness and evident satisfaction.)

"Our ideas of Mars," said Murray, "change with tremendous speed in succeeding years. Quite recently, Mars was considered to be older than earth, and it was said that the great mission of earthmen is to breathe new life into the decrepit civilization of the red planet. In the middle of the 1960's, it appeared that Mars was /204 rather reminiscent of the moon: a very thin atmosphere (the pressure on the surface of Mars corresponds to the pressure on earth at an altitude of 30 kilometers), there is no constant magnetic field and there are no radiation belts. The severe landscape, with a large number of craters, reinforced this similarity still more. Some sort of average moon resulted. We thought this quite recently, in July of 1965, when our Mars first-born Mariner-4 flew. Yes, and after 1969, when Mars was photographed by the 6th and the 7th Mariners, this point of view was most widespread, though, in my opinion, these craft increased our knowledge of Mars a hundredfold. And then Mariner-9. Now, we know still another hundred times more about Mars. And we now know that Mars is not similar to the moon. In general,

it is not similar to anything. Mars is similar to Mars. . ."

Let us transfer ourselves mentally from the cheerful office of Bruce Murray to the recent past, to 13 November 1971, and let us imagine ourselves to be in the chilly, windowless unmanned space vehicle control room in Pasadena. The huge 63-meter bowl of the radio telescope in Goldstone picked up the weak radio pulse of Mariner-9 at this moment, amplified it and sent it to the Pasadena computer, which converted the Morse code figures into an image with lightning speed. The television screens flashed on."

"We saw the dim, somewhat rusty color of the image," remembered planetologist Robert Steinkaker, "It was clear that Mariner was showing something interesting, but we could not make out details . . ."

The video signal received was again sent to the computers, which removed interference from it and performed a unique electronic touch-up, intensifying the shadows and bleaching the light places.

A unanimous sigh of relief resounded in the room, when, after a minute, a new picture appeared on the screen. Everyone clearly saw a fragment of Mars, a few craters, surrounded by a desert plateau.

Thus was born the first of 7,329 photos, which were transmitted to earth by Mariner-9, during its time of operation in Mars orbit, from November 1971 to October 1972 (for comparison: in 1965, Mariner-4 transmitted 22 photographs). It took in the entire planet, which now permits the first globe of Mars to be built. So, what can be seen in these photos?

It turned out that, despite its modest dimensions, compared with those of earth (diameter of Mars is a little over half that of earth, and the mass of the red planet is only 11% of the mass of earth), the relief of Mars is very much more broken. In the great hall of the main building of the laboratory, a huge photograph of the volcano, Nix Olympia, hangs; it is one of the best photographs of Mariner-9, in which are depicted mountains, which actually are completely unique. There are no similar mountains on earth. If the oceans of earth were to dry out, the highest mountain would prove to be Mauna Loa volcano in Hawaii. The distance from its foot at the bottom of the ocean to its present peak is about 9 kilometers and the diameter of the base is 225 kilometers. The height of Nix Olympia is 23 kilometers. When Mariner-9 reached Mars, a dust storm was raging on the planet, but, nevertheless, the peak of Nix Olympia was seen. The diameter of the base of Nix Olympia is 600 kilometers. The crater alone at the peak of this tremendous bulk has a diameter of 65 kilometers. Three smaller volcanoes, but also gigantic ones, are located side by side. Earth does not have the equal of the huge fracture, which goes along the equator of the red planet like a scar. Its length is such that, on earth, it would cross the United States from ocean to ocean. The width is 120 kilometers and the depth is up to 6 kilometers. For a comparison, the famous Grand Canyon in Arizona, one of the wonders of the world, has a maximum width of

21 kilometers and a depth of 1.6 kilometers.

There generally turned out to be many formations on Mars, reminiscent of ravines and channels of dried-up rivers. However, even for this mysterious planet, another canyon, stretching for hundreds of kilometers 300 miles south of the equator is unique. It is branched, like the branches of a tree, and it appears that a vigorous mountain stream abandoned it only yesterday.

A strange plateau, with an area of over 8,000 square kilometers, solidly covered with sand dunes caused very great interest among the scientists. It looks like a congealed ocean: tremendous sand waves roll in even rows, at a distance of approximately one and a half kilometers apart. This desert is at the bottom of a crater, 150 kilometers in diameter, in the so-called Hellespont region of Mars. As in our deserts on earth, the boundary dunes are smaller than the central ones. Their strict orientation allows it to be considered that they were created by constantly blowing, strong southwest winds. /205

Mariner-9 succeeded in photographing both Martian poles. A large plateau is distinctly seen at the south pole, which, in the opinions of specialists, may cover huge stores of water. A denser layer of volcanic dust, covering deposits of solid carbon dioxide (that same "dry ice," which is used by ice cream vendors) possibly lies beneath a light cover of dust-storm drifts, and frozen water may lie below it.

Mariner-9 flew during the Martian spring; therefore, the white cap of the north pole gradually decreased, disclosing a complex system of sedimentary rock . . .

Look at these photographs, and you will be like in childhood, pressing, flattening your nose to the glass of the aquarium in the zoo, beyond which lies a completely mysterious, alien and secret world. You experience a fearful desire to penetrate into it, to step on this cold, dry sand, to descend along the steep precipices of the canyon, to run on the peak of the crater, and how easy it is to run: Of my 75 earth kilograms, only 28 and a half overall remain on Mars. A fast, but weak, rarefied wind whistles in the headset. You are on Mars! Just think, I believe that this fantastic good fortune of discovery of a new world will fall to someone among people already born, already living somewhere among us!

Here, for him, this earthman, unknown up to now, this whistling, enthusiastic man worked, who initially paid us no attention at all, when we came up to see how the first globe of Mars is being born.

Despite the fact that Mariner-9 related very much new about Mars to earth, the "main question of Mars" remains open. In fact, is there life on Mars?

The spearshafts broken in controversies on this subject could constitute an entire forest on Mars, noticeable in terrestrial telescopes. But alas, of actual forests on Mars, no one has seen proof of their existence, beyond question in the opinion of some specialists, and it appears very doubtful, if you talk with others.

Seasonal changes in the coloring of individual regions of Mars have been determined absolutely accurately. Widely known is the explanation of this phenomenon given by Soviet astronomer G. A. Tikhov, a convinced advocate of the existence of Martian vegetation. The more cautious Englishman, Patrick Moore, vaguely implies that the dark regions formed after falling of the polar caps behave as though they were "awakening from a deep winter sleep."

Not devoting themselves to the centuries-old history of the question of life on Mars, which could become the subject of an exciting popular science novel, with a large number of brilliant heroes, they dwelt only on the disputes, which have been going on among the Americans themselves in recent years; these disputes have not directly, but indirectly affected the engineering thought of Pasadena and, to one extent or another, have dictated the requirements for purely applied, design developments of the Jet Propulsion Laboratory. (It is not necessary to be a specialist, to understand how much they affect these developments and all other definitions of the parameters of the Martian environment: temperature, atmospheric gas composition and its pressure, soil structure, etc.)

Thus, in the recent past, a serious attack has been undertaken on the advocates of the existence of Martian vegetation. Their opponents, referring to the authority of the outstanding Swedish chemist, Arrhenius, have asserted that the seasonal changes of individual regions of the planet are in no way connected with Martian flora. In their opinion, everything was far simpler. During the melting of the polar cap, the soil absorbed moisture, and some sections, moistened in this manner, darken. The astronomer Epik reasonably objected to it:

"If this is wet soil, why does it not change its color after the dust storms? Well, these moist sections are covered with dust. /206 And they exist from year to year, regardless of the Martian dust storms. Would it not be correct to consider that this is still some vegetation forcing its way through the dust layer?"

The discussion developed.

Frank Salisbury, professor of plant physiology of the University of Colorado, was, for example, a fierce partisan of the development

of Martian life. He categorically disagreed with his California colleague, professor of chemistry, Nobel laureate, Harold Urey, who wrote of the "very low probability of life on Mars, in those forms, which are the most active on earth." The simple anaerobic³ world of Urey does not suit Salisbury. "The lowest terrestrial forms of life, such as moss, algae and various microorganisms, could not form colonies visible from earth," writes the physiologist. He notes that terrestrial lichen hardly change their colors and grow extremely slowly. A reasonable question: Why, under the incomparably more favorable conditions of earth, do lichens grow for about 25 years and in so many days on bleak Mars? It means that these are not lichens. Analyzing photographs of earth, made from high altitudes, Salisbury came to the conclusion that, strictly speaking, only the thick forest and rich meadows of our planet appear as green sections. "Therefore," he wrote, "it can be considered that the changes in color and size of individual sections of the surface of Mars observed from earth indicate the existence of luxurious vegetation on the planet and not lower vegetative forms at all, as other scientists frequently suppose."

However, the "opponents" did not stop. If you please, the so-called volcanic theory of MacLaughlin, originating, to the honor of its author, even before photos proving the existence of Martian volcanoes were received in Pasadena, seemed to be more or less likely to them. MacLaughlin explained the darkening of separate sections of the planet as whims of the wind, carrying a large amount of volcanic dust with them. Not that he denied the possibility of the existence of vegetation in the soil, fertilized by volcanic ash and even by cooled lava flows. In 1960, Carrer and Kiss created what was, at first glance, a quite well-composed theory, according to which all the color differences were explained by nitrogen oxides. Bluish nitrogen tetroxide, in their opinion, covered the polar caps. The planet was blanketed in brown clouds of the dioxide, mistakenly taken for dust storms. Accumulating in the depressions and crevices, they created dark regions. However, a spectral analysis by the "proponents" did not confirm this hypothesis. Moreover, it was in obvious contradiction to the principles of thermodynamics, in all likelihood, just as true for Mars as for earth. The proposed structures could not be in energetic equilibrium.

Finally, the "opponents" could have been considered to be finally beaten, when the American Sinton directed the huge Palomar reflector to the so-called Syrtis Major, an extensive lowland not far from the Martian equator, and analyzed the infrared radiation reflected by the dark regions of Syrtis. Absorption bands characteristic of organic molecules were found in three ranges. The first absorption band of Sinton, Salisbury would have said, not in reproach, nevertheless, was identified with terrestrial mosses and algae. The

³Anaerobic bacteria are a particular type of bacteria, which can exist in an environment devoid of oxygen.

second was a little reminiscent of the spectrum of one of the varieties of lily and of cactus. A terrestrial analog of the third could not be found.

The "proponents" took heart. Let it only be moss, but not volcanic dust! Yes, if it is thought to be just moss and cactus, these classical examples of modesty and the ability to survive, by the logic of matter, they should more easily endure the severe conditions of Mars: sharp fluctuations in temperature from -100 to +30°, dryness and scanty supply of oxygen in the atmosphere.

This reasoning was supported perfectly by the interesting tests of Sanford Siegel, biologist and chemist, who performed a big set of trials, to test adaptability of terrestrial plants to Martian conditions. In a phytotron, an apparatus recreating the approximate atmosphere, temperature and soil conditions of Mars, Siegel grew not only lichens, but, which was thought far more fanciful, rye, wheat, beans, rice and even cucumbers. The plants grew and developed! Mint, for example, felt better "on Mars" than on earth. Siegel reached still another very important conclusion for the "proponents": with decrease in the amount of oxygen in the surrounding atmosphere, many terrestrial plants withstand the harshest frosts better. Consequently, taking the severity of the Martian climate into consideration, oxygen starvation is not bad, but good for life!

But here, the almost beaten "opponents" succeeded in proving that the tests of Sinton were not pure, that this same spectrum can be obtained under certain specific vapor conditions of the terrestrial atmosphere and that Mars is nothing here . . .

The web of theoretical interpretations of new and old experiments could be woven further. I have taken principally only the dispute of the Americans in comparatively recent times. It must only be said how much the spectrum of the disputes would be increased and diversified, if we had mentioned the works of the scientists of the USSR, England, France and other countries. Right away, speaking of the work of our Soviet colleagues, Doctor Murray noted that the majority of the Soviet planetologists "are in the realm of the physicists," while the Americans consider the planets from the point of view of science on earth.

"And this is very good," he added, "a different approach guarantees completeness of research . . ."

However, in the samples presented, in no way pretending to complete interpretation of the question, something more general, a certain sober caution, rationality and skepticism can be noted. All the victories of theory and experiment have led ultimately to the situation that, today, there evidently are, nevertheless, fewer proponents among scientists of the existence of highly organized life on Mars, than during the time of Sciaparelli, the first "examiner" of the Martian canals. "Although the facts are in favor

of the theory, by which existence of at least some forms of vegetable life are possible on Mars," the American meteorologist George Oring correctly notes in his book Weather on the Planets, "It seems very modest, in comparison with the thought of individual scientists at the start of our century, who were firmly convinced that there is not only life, but intelligent beings, on Mars."

Today, no one dreams of "brothers in intelligence": We do not find them on Mars. But life? Even the most primitive, plants, moss, some kind of tiny mushrooms, yes, even if only bacteria, ultimately! Even something that is born, grows and dies. If there is something similar on Mars, it means that a tremendous diversity of life in the universe will be proved experimentally; philosophically, ideologically, the importance of such a discovery is tremendous.

In the five centuries since the birth of Copernicus, we have finally parted with the ideas of the earth as the center of the universe. We have parted heart and mind. But every time, as soon as talk turns to life on other worlds, we return, to a certain extent, to the epoch of geocentrism. "No, it stands to reason, life exists in the universe, the number of inhabited worlds is huge," we repeat after Giordano Bruno, and we understand intellectually that this actually is so. But we are convinced in our hearts that there is nothing better for the triumph and progress of life, than our beautiful green earth, there is not and can not be. We simply love it too much, to come to believe that something unacceptable and hostile to us, but suitable and favorable for other forms of life unknown to us can exist. Perhaps what we call "higher organisms" are not so high, and the upper stages of terrestrial evolution may prove to be down the evolutionary ladder on other worlds. I say this, but I do not believe it, I understand that it is difficult to believe in this. Even not to believe is difficult to accept. Our love (like any love) interferes with our objectivity.

I cannot prove this with graphs and spectrograms in my hands, but I am convinced that life exists on Mars, not only in the form of bacteria and spores. I am convinced that the uncommon plasticity and great adaptability of living things are capable of overcoming, not only the severe conditions of existence on the red planet, but of taking root in an environment, which is still more improbable, terrible and impossible for life, from our terrestrial point of view. And I very much hope to live until the day, when I can be sure of this.

This dry lake is in California, 45 miles to the northeast of /208 Barstow. The dry, cracked earth would not attract lovers of country walks, and here it was Monday, early in the morning, and there was not a soul around. However, if anybody were there, he would notice a low-flying helicopter from far away. Here, it is still descending. It was still 80 meters from the ground, when some object very reminiscent of a wheel separated from the helicopter, so that it

might appear to a detached observer that the helicopter was falling apart. The "wheel" crashed into the hard ground with a hollow noise. And, if our curious observer now came closer and listened, he probably would be able to detect a faint buzzing, coming from the hub of the "wheel": The radio transmitter was operating.

All this took place in April 1968. The Jet Propulsion Laboratory had perfected an apparatus, intended for a landing on Mars. It passed the test successfully. Despite the fact that a parachute was not used and that the speed of encounter with the earth was at least 130 kilometers per hour, the radio transmitter remained intact and operated for a period of an hour.

In Pasadena, these tests were called an "important step in the program, which must prove the viability of the plan for sending a light landing capsule with scientific instruments to Mars in the near future." The "near future" extended to long years. The landing capsule, similar to a wheel, thus, was not sent to Mars on the next Mariner. But Pasadena is not guilty of this.

It was well understood in Pasadena, that the best and most detailed maps, the greatest victories of marsography, nevertheless, cannot be compared to solution of the problem of life on the red planet. For a period of many years, the Jet Propulsion Laboratory was tirelessly occupied with selection of the key to this hiding place, in which almost the innermost secret of the solar system is preserved.

In the middle of the 1960's, NASA planned to send the Voyager unmanned spacecraft, weighing more than three tons, which is approximately 6-7 times heavier than present interplanetary spacecraft, to Mars, by means of the most powerful American "moon" rocket, the Saturn-5.

The giant unmanned spacecraft had to consist of two sections, one of which remains in Mars orbit and the other which descends to the planet. An automatic meteorological station, an atmosphere analyzer and, which is especially important, apparatus for detection of traces of life had to be aboard this section.

A tiny portion of Martian soil must be placed in a nutrient broth. If there are microorganisms in it, they multiply in the broth and, thereby, cause clouding of it, which can be recorded by television apparatus. In another experiment, it was proposed to find traces of photosynthesis. This basic life process on earth, converting carbon dioxide and sunlight into matter, in the thoughts of the experimenters, possibly operates on Mars. A sample of Martian soil was proposed to be treated with a strictly measured amount of carbon dioxide, night and day, and, then, to test, whether or not the amount of gas changes. If the gas decreases in the daytime and not at night, this means that the process is taking place. The test can be modified. Since all life on earth gives off carbon dioxide in living activities, a comprehensive gas analysis of the

soil sample could also give interesting results. Television cameras and microphones supplemented all this apparatus.

The flight of Voyager was planned for 1973. However, as you know, this did not take place. This was mainly because, it seems to me, Voyager was torpedoed by Apollo. Severely shaken after launch of the first artificial earth satellite in the world and the flight of Yuri Gagarin in the USSR, the "space" prestige of the United States forced President J. Kennedy to declare the program of the landing on the moon to be a national program. In the middle of the 1960's, when work on Voyager began, all of the principal personnel and the material resources of American astronautics were transferred to Apollo. These unusual efforts were crowned with success in July 1969, when Neil Armstrong first stepped onto the moon. The five subsequent voyages to the moon consolidated the success of the program.

The Americans themselves acknowledge that Apollo is mainly a prestige and, only then, a scientific program. In December 1973, for example, turning to past events, the American reviewer, John Wilford, wrote in the newspaper, The New York Times: ". . . the Americans accomplished the flight to the moon, not so much for the purpose of studying it, as because they wished to 'get ahead of the Russians'. . . Even some advocates of space research acknowledge that the country possibly committed an error in accomplishing the Apollo project at such a lightning speed and for such colossal amounts of money. These unbalanced efforts led not only to the situation that, an incorrect impression was formed among the population, that Apollo was a space program." /209

Alas, one of the numerous victims of these "unbalanced efforts" was the Voyager project, the purely scientific importance of which upon successful completion of it, I think, might surpass the scientific importance of any of the lunar expeditions, with all the wealth of material gathered by them.

On 3 July 1969, in an editorial article, "Reconnaissance of Mars," the newspaper, The New York Times, wrote of the direct threat to Pasadena: ". . . the American political leadership was so absorbed in the program of landing a man on the moon, that unmanned exploration of the planets became the stepchild of the national space program. There were times, when even the further existence of the Jet Propulsion Laboratory, the unmanned space flight center, appeared to be doubtful."

However, Pickering and his comrades in California did not rest. After some time, there appeared in Pasadena a new project, worked out in all details, which was named Viking.

The overall scheme of the Viking flight to Mars and landing of the descent section on its surface differed from the Voyager scheme in technical details, which are of interest only to specialists. If you please, the most significant difference in these two projects

is the carrier rocket. NASA cannot grant a Saturn-5 or Viking, since these rockets were used up on the lunar Apollos, and building new ones threatens too great expenditures. The number of Saturns at present is measured in units. One of these numbered rockets has been allotted, for example, for the joint Soviet-American Soyuz-Apollo program. Therefore, a Titan-3E-Centaur rocket, of more modest dimensions is being prepared for Viking. While Saturn-5 could send a useful load weighing 36 tons to Mars, the new rocket is capable of sending one-tenth as much into Mars orbit. In this manner, Viking is at the limit of the carrier capabilities in its weight characteristics.

However, all this would be nothing, if Titan-3E-Centaur already existed. In the meantime, this hybrid rocket, a certain mean between the actually existing Saturn-5 and Atlas-Centaur, is in the test stage.

While Saturn-5 has proved to be good, this cannot be said of the Atlas. This rocket has already been used during launches of unmanned interplanetary spacecraft. In the opinions of the Americans, the Atlas rocket, if you please, is the most capricious of the American rockets. Like a dirigible, it continually needs internal overpressure, in order to retain the rigidity and strength of its structure. Depressurization of the Atlas is a very serious affair. For example, in February 1969, during preparation for the launch of Mariner-6 towards Mars, an emergency pressure drop inside Atlas was the appearance of "wrinkles" on the hull of the rocket, which was made of stainless steel, no thicker than the sheet of paper on which this article is printed. The rocket then had to be replaced. Therefore, all sorts of unpleasant surprises can be expected of the Atlas, which the space writer of UPI, Rossiter, ironically once called a "unique rocket." It is difficult to tell what will be obtained, as a result of this rocket hybridization; a hybrid is only bred. The first experimental flight was set up in February of this year, and it proved to be a failure: The second stage of the rocket failed.

The absence of an actual carrier does not interfere with talk of Vikings as a settled matter in Pasadena. A quite detailed plan of preparation for this experiment has been compiled. More precisely, of experiments, since the launch of two identical craft is planned. One of them begins the prelaunch test stage at Cape Canaveral in November 1974. In January 1975, this unmanned spacecraft, together with the carrier rocket, will be set up in launch complex No. 41, especially re-equipped for a new rocket, where the prelaunch tests of all systems will continue. Then, it gives way to the other rocket, with another Viking, which is to be launched 11 August 1975. The second launch will take place approximately 10 days later. /210

Two interplanetary spacecraft significantly increase the probability of success of this experiment. If their almost year-long journey to Mars goes favorably, so much the better: Two areas of the planet can be explored at once.

The landing area of the first Viking has been chosen in a valley, not far from the mouth of the great Martian canyon. An entire network of canyons and ravines scatters from this valley, lying in an area of systematic seasonal darkenings and being approximately 5 kilometers below the mean level of the surface of Mars. "Possibly," writes the scientific correspondent of the Washington Post newspaper, Thomas O'Toole, "a drainage system for the equatorial regions of Mars was here, in its time." If it is permissible to speak of moisture under the conditions of Mars, this place is equivalent to the Congo or Amazon basins on earth.

The landing area of the second Viking has been selected still lower. It is 5760 meters below the mean level, approximately 1600 kilometers to the northeast of the first landing. The snow of the north pole of Mars borders this region. Something reminiscent of clouds, which, as it is hoped, may occasionally moisten the Martian desert, can be observed more often here than in other places.

Using the language of the astrologers of the Middle Ages, the position of the heavenly bodies favors this experiment. It is favored in the propaganda plan. The mutual locations of the earth and Mars allows the launchtime to be calculated in such a manner, that the first Viking will land on Mars on 4 July 1976, on the day of the great national celebration of the two-hundredth anniversary of the United States. It goes without saying that this will be a good gift to the holiday, although it is not cheap: The cost of the program is approaching a billion dollars.

The delight of the organizers of the approaching celebration, plotting the holiday course of the Vikings, is by no means shared by the space communications specialists. The fact is that Mars will be on this side of the sun in the summer of 1976, at a distance of approximately 330,000,000 kilometers from the earth. Unmanned spacecraft are turning out to be completely "homeless." Earth cannot control them at distances which radio signals travel in forty-five minutes. In this manner, such a complicated stage of the flight as separation of a section and landing of the descent vehicle on the surface of Mars lies entirely on the shoulders of the onboard command computer. Only after forty-five minutes can earth know how successfully their sterilized laboratory "touched down on Mars" (not knowing what contamination of the alien planet environment by terrestrial microorganisms might threaten, it has been decided at NASA not to send spacecraft to other planets, without preliminary sterilization, until at least 2018).

If everything goes well, the automatic laboratory should operate on the surface of Mars for at least three months, according to the plan. Its two television cameras should regularly send color Mars panoramas to earth. Special analyzers will attempt to determine the precise composition of the atmosphere. Seismographs will "listen" to the planet, meteorological equipment will relate the Martian

weather. Tiny, mechanical manipulator-arms will begin a series of biological studies.

Thus, we will wait and see whether or not the terrestrial broth is darkened by Martian bacilli. And if it is not darkened? On this point, as one American scientist stated, "It is just as important to find no life on Mars as to find that there is life." This is true. Nevertheless, it seems to me, the words of a popular lecturer from Carnival Night: "Science still does not know whether there is life on Mars or not," may remain true at the end of the Vikings. As a matter of fact, you must agree that a biological analyzer similar to the Viking analyzers, installed in certain regions of such a planet as earth, luxuriant with life (high mountains, desert, polar regions), might not find life in it, to say nothing of the fact that the Martian microorganisms, of which we know absolutely nothing, may not multiply at all in the terrestrial broth, but, on the other hand, die in it. The launch of the third Viking, which now is planned for 1979, must be considered to be a unique control test. Assume that we receive some response, by means of the automatic machines. At the same time, it certainly could happen that different automatic machines give different responses. But assume all the responses are identical. How come?

I believe that a negative response will convince us of nothing. A positive one, I also am convinced of this, will certainly give rise to the suspicion: Are these not terrestrial microbes, transplanted to Mars by the spacecraft itself, despite all the sterilization contrivances? And the question will arise without fail: Were not the optics darkened instead of the broth, and did not some inorganic coloring substance found in the soil dissolve in it? An infinite number of such questions can be thought of and, with all the perfection of the Pasadena apparatus, Viking cannot give answers to all these questions. True, if we are very lucky and we see something unquestionably alive by means of the television cameras, this is convincing. In any case, the tests with the broth are far more convincing. However, here, we actually have to be devilishly lucky!

Of course, a single positive response will multiply tenfold our all-conquering terrestrial curiosity, and it will give new force to those, who will prepare the first Martian expedition of earth people. Not so much doubt of the capabilities of the skilled craftsmen from Pasadena, as knowledge of the windings of human psychology whispers that only such an expedition can provide an end to the great controversy over life on Mars.

I've always considered any contrasting of the operation of unmanned interplanetary spacecraft and manned spacecraft to be inappropriate and foolish. Interchangeable tasks are difficult now for one or the other of them. However, a short history of astronautics shows that the path of man is paved with automatic machines. Thus it was with orbital flights around the earth: Gagarin flew after the artificial satellite. Thus it was with the moon: Armstrong stood on its surface after Luna-9. Thus it will be with Mars. And not a one of the most perfect automatic machines will ever tell

us as much about the red planet as a man can tell.

Pasadena understands this well, considering the Mariner flights completed and the future Viking launches as overture to the heroic epoch of the journey of earthmen to Mars.

In January 1961, the New York Herald-Tribune published a quite irresponsible report that NASA was planning to launch a gigantic rocket, weighing 613 tons, with an atomic power unit, on 19 May 1971. Assembled in orbit of an artificial earth satellite, the 70 meter rocket would supposedly carry a crew of seven men to Mars. Perhaps some of the journalists took the first rough estimates as a plan and, perhaps, it was simply the usual American newspaper bluff, I don't know. I only know that they then tried to forget about the 1971 Mars expedition.

To speak seriously, the future Mars expedition is in the stage of initial, rough outlines. It is clear that such a flight cannot stand outside other space programs. It is connected in the closest manner, not only with successful flights of the unmanned interplanetary spacecraft referred to, but with problems of prediction of solar activity and with the results of prolonged medical-biological investigations in space and with progress in the field of building long-lived orbital stations. It is precisely these stations which obviously will be the space moorings to which the Mars spacecraft will make fast.

However, beside all the scientific-technical factors dictating the conditions of the Mars expedition, there is still another factor, alas, which is completely independent of us: The mutual locations of the planets do not always permit us to start for Mars. The distance between earth and Mars during their opposition ⁴ changes very severely: from 56 million to 102 million kilometers. In recent years, Mars approached closest of all to us on 10 August 1971 (56.2 million /212 kilometers). The dates of the next approaches are 15 December 1975 (84.6 million kilometers), 22 February 1978 (97.8 million kilometers). The Americans consider that the earliest possible date of launching people toward Mars is 12 November 1981. Then, the spacecraft achieves an orbit of the red planet on 9 August 1982, where it should be for approximately three months. In this time, they can touch down on Mars in a special little "excursion" craft. Finally, completing their return flight, the terrestrial "Martians" should tie up to the orbital station on 14 August 1983.

In the initial rough drafts, for example, a version with two spacecraft, designed for 12-man crews, is being studied. However, allowing for possible accidents en route and the necessary subsequent transfer, only six men take off in each craft.

⁴That location of the planet, when Mars, earth and the sun are approximately in a straight line is called opposition.

A special little "excursion" craft, designed for a crew of from three to six men (how they actually might be envied!), is launched from satellite orbit toward Mars after an unmanned spacecraft, lowered beforehand to the planet, again confirms that nothing threatens the astronauts. The astronauts will be on Mars about two months. That, in the most general outlines, is one possible version.

I mention it so superficially, because these are manned flights, with which the California Jet Propulsion Laboratory has no direct relationship. Nevertheless . . .

The scale of the future expedition of people to Mars, unprecedented in the history of mankind, more and more often leads to the thought that it can be accomplished, only on condition of prolonged peace and the closest scientific-technical cooperation. The grandiose nature of what has been conceived, by all the evidence, proves that such an expedition can scarcely be accomplished in isolation by any one country, that exploration of the entire planet Mars is a matter of the entire planet earth.

Far-sighted Americans spoke and wrote long ago, before the first landing on the moon, of the fact that an expedition to Mars must be an international expedition. In the summer of 1969, the newspaper New York Times stated the question in one of its headlines: "After Apollo, Mars?"

"In comparison with the expenditures connected with an expedition to Mars," the newspaper wrote, "the 24 billion dollars, which were spent on the Apollo project, appears to be a vanishingly small sum . . . any forced Martian version of Apollo would require hundreds of billions of dollars, which are needed more to satisfy the requirements of people on earth, where the most diverse problems have to be solved, from control of poverty to control of air and water pollution and provisions of the proper level of education, medical service and nutrition. It will be sad," continued the newspaper, "if a manned flight to Mars is accomplished under the conditions of the same extravagant national rivalry as accompanied the flight to the moon. Such a project makes sense, only if it is accomplished on a genuinely international basis . . ."

A little later, the Chairman of the House of Representatives Commission on Problems of Science and Technology, the Californian George Miller said: "When flight to other planets becomes an engineering reality, there are chances that Russia will combine with the United States in accomplishing the flight to Mars as an international expedition."

When we were in New York, I was shown another newspaper, published on the eve of the first American expedition to the moon. It was already known then that Armstrong and Aldrin would leave five symbols on the moon, in memory of the dead astronauts, three Americans and two Soviets. And the newspaper wrote this: "How much better it would be, if sometime in the future, the first spacecraft carried

living Americans, Russians and citizens of other countries to Mars, as representatives of all mankind in this greatest of human achievements."

These words pleased me. I rewrote them in a notebook and did not think of them a single time in Pasadena. Whoever engaged us in conversation there on the future flights to the red planet, it always ended with a friendly slap on the shoulders and the indispensable exclamation:

/213

"Of course, we fly to Mars together!"

The first, if now very modest, test of cooperation in study of the planet already exists.

An agreement on exchange of photographs of Mars, reached during the joint flight of the three interplanetary spacecraft, the Soviet Mars-2 and Mars-3 and the American Mariner-9, celebrated a new landmark, not only in study of the red planet, but in the history of Soviet-American scientific cooperation. The newspaper Washington Post evaluated this agreement in precisely this way, asserting that it "is the first agreement of this kind in the fourteen years of the space age."

It can be said confidently: This is a healthy beginning.

4

Mr. Donald Ray, assistant director of the Jet Propulsion Laboratory of the California Institute of Technology, flipped the button of the slide projector the last time, the screen, on which a second ago a Martian abyss, photographed by Mariner-9, gaped before us, went dark, light flashed on in the room, everyone blinked and, when we opened our eyes, Mr. Ray was already sitting behind a desk and smiling.

Thus began a press conference, set up for us by the American specialists in Pasadena. However, we did not begin it, but Mr. Ray himself. It turned out that, two years ago, he took part in a scientific symposium on study of the planet in Moscow, and first of all he asked us to send greetings to the "two Soviet academicians Petrov," Boris Nikolayevich and Georgiy Ivanovich, our leading scientists in the field of astronautics, conversations with whom he remembers with great pleasure.

"And now, please ask questions, gentlemen . . ."

There were many questions. On the Mars photos, from matters of the past, it very quickly changed to affairs of the near future, and our conversation was launched into other orbits, in the literal and figurative senses.

I began these remarks with a story of the study of Mars, not only because Mariner-9 gave an excellent occasion for it, but because the Mars program of Pasadena, if you please, is the most interesting and promising. However, this does not mean that the Jet Propulsion Laboratory has concentrated all its efforts on the red planet. In a conversation with Mr. Ray and other specialists, three main directions in development of automatic planetary explorers were very quickly defined: Mars, following behind it the giant planets, mainly Jupiter and Saturn, and the so-called innerplanets, Venus and Mercury.

They have been occupied for a long time in Pasadena with Venus, the nearest neighbor of earth. The Mariner-2 (1962) and Mariner-5 (1967) unmanned Venus spacecraft were built here. Both studied the planet from a so-called flyby trajectory, which, considering the nature of Venus, cannot be considered the most fortunate one for exploration of it. And here is why.

It is precisely about this planet, located closer to us than the others, that less was known until very recently, than of "relatives" in the solar family, incomparably more distant from us. The thick, almost impenetrable (the clouds on Venus reflect 70-80 percent of the sunlight incident on the planet) atmosphere of Venus hides the planet tightly from terrestrial observers and from the "eyes" of unmanned spacecraft at the moment of their flyby. Examination of the planet from nearby, which enriched our knowledge of the nature of Mars so much, does not have a similar effect here. Only by means of successful flights of several Soviet interplanetary spacecraft, the first one of which was Venera-4 in October 1967, which accomplished a parachute descent of equipment to the surface of the planet, was the list of its mysteries considerably reduced. It is known confidently now that the temperature on the surface of Venus is in the 400-530° range, and that the pressure fluctuates between 60 and 140 atmospheres. The atmosphere of Venus consists almost entirely of carbon dioxide. Its composition includes small amounts of nitrogen, the noble gases, oxygen and water vapor. Particles of concentrated sulfuric acid were found recently in the upper layer of the clouds of Venus.

We especially want to emphasize the achievements of the Soviet 214 unmanned spacecraft, because, in distinction, let us say, from Mars, the principal parameters of the atmosphere, which were determined with more or less accuracy by astrophysicists on earth, long before the start of space flights, almost nothing was known of Venus. Suffice it to say, that the same astrophysicists were 400° in error, in determination of the temperature on its surface. It seems to me that, for designers of Venus descent craft, it would be generally better to know nothing, than to know what astronomers could give them during the period when this craft was being designed. I will never forget these truly "starry minutes" in the Deep Space Communications Center, during which the Venera-4 descent craft told us more about the secret planet than was known in the entire history of mankind. And, while Doctor Murray considers that the Mariners increased our knowledge of Mars a hundredfold, I hasten to state that Venera-4 increased our knowledge of Venus a thousand times.

However, I repeat: Each country goes and is on its own way, in planetary expeditions of unmanned spacecraft, and science only wins, if these paths do not duplicate each other.

"The day following the descent of the Venera-4 descent craft into the atmosphere of Venus, the American unmanned spacecraft Mariner-5 flew up to the same planet and began to explore it, from outside," was noted in one of the scientific commentaries of TASS, "two countries, two different methods and, as a result, the richest scientific material, leaving no doubt as to the accuracy of the data obtained, eliminating any element of chance."

However, whatever methods were used for study of Venus, it already is clear that the stifling, dark, scorching world of the "morning star," places difficult to overcome obstacles in the path of penetration of man to this planet. In any case, these obstacles cannot be compared with those, which are seen before the Mars expeditions of earthmen. And, while Mars expeditions, in their main outlines, are today within the framework of engineering reality, this cannot be said of expeditions to Venus. I think that, in the 20th century, Venus will be entirely given over "to the control of" unmanned spacecraft.

Interest in study of this "uncomparable" planet evidently is somewhat further decreased, because, in the opinions of specialists, there is practically no hope of discovering even primitive forms of life on Venus. Some of the scientists, for example, the American astronomer C. Sagan, and the Soviet astronomer I. S. Shklovskiy, whom I have already mentioned, consider that there is more basis for finding life on Jupiter than on Venus.

Nevertheless, it is considered in Pasadena that exploration of Venus must continue at faster and faster rates.

The unmanned spacecraft Mariner-10, or MVM-73, as it is called at Pasadena, where all the technology of building it was developed, which was then put into practice by the Boeing Company, was launched from Cape Canaveral on 3 November 1973. True, it could be noted immediately that the "wings" of its solar batteries were as though they had been clipped. However, it is flying, not away from the sun, but toward the sun, and its energy consumption can be provided by a smaller photocell surface. Immediately after the launch of Mariner-10, several photographs of earth and the moon were transmitted; this was the "aiming" of its onboard television cameras, and it then lay on course to Venus.

This unmanned spacecraft continued the study of Venus from a flyby trajectory, which has become traditional for Americans, to a certain extent. Flying past on 5 February 1974, at a distance of 5736 kilometers from it, Mariner-10 examined Venus, by means of two television cameras, developed especially for it at the California Institute of Technology, and it transmitted 3712 photos.

On the background of the bright clouds of Venus, some dark spots were successfully photographed, the origin of which no one has tried to explain. They speak of apparatus defects (this also is already the "traditional" explanation of anything which cannot be understood). Journalists visited Bruce Murray, who directed the photography of Venus and asked for commentary from him. To the extent that it was easy for Murray to converse with us about Mars, it²¹⁵ was that difficult for him to say anything definite about Venus. The only thing of which he was sure was that the black spots are not the surface of Venus. Its atmosphere is too thick and dense to permit Mariner-10 to succeed in finding a "window" in its clouds.

However, one of the orientation gyroscopes disturbed more photographs this time. Its breakdown, eight days before the approach to Venus, led to unforeseen consumption of compressed nitrogen, on which the orientation motors operate. There was a plan not to orient Mariner-10 at all for photography of Venus, in order to economize on nitrogen, to carry out the most interesting part of the planned program. In distinction from the preceding Venus Mariners, the final destination of the tenth one is much beyond the clouded planet. The launch date was selected, not only based on the locations of Venus and earth. A new course was coded in the Pasadena MVM-73 index: Mariner -- Venus-Mercury 1973. In addition to Venus, this space explorer was called on to begin direct study of Mercury, the first planet of the solar family.

All the difficulties to which observers of Venus usually refer hold true for Mercury to a still greater extent. The nearness of this planet to the sun interferes extremely with astronomers. Mercury is seen relatively well before sunrise and after sunset, but it then is very close to the horizon, and one trouble (the blinding light) is replaced by another one, the dense layer of the earth's atmosphere. All this explains the scantiness of our information about this planet.

It is known that Mercury approaches the sun to within a distance about half that of the earth. With the given name of the ancient Greek god of commerce⁵ who always is depicted with tiny wings on his ankles, speedy Mercury races in its orbit with record speed for a planet, more than 200,000 kilometers per hour. It was considered for a very long time that the period of rotation of Mercury about its axis was equal to the period of its revolution around the sun, in other words, Mercury always turns one of its sides to the sun, similar to the way in which the moon always has one side facing the earth. It was only in 1965 that G. Pettengill and R. Dyce determined, by means of radar methods, that this is not so at all. It turned out that Mercury performs unique pirouettes in the planetary round dance, completing

⁵[Translator's Note: Ancient Greek Hermes; ancient Roman Mercury.]

three turns around the axis for each two revolutions around the sun. A very unusual calendar results: three days equals two years (or 15 days equal 10 years, which boggles the imagination). This is an extremely important discovery. If there exists some periodicity of illumination of various parts of the planet by the sun, it means that, not only temperature, but the climate of Mercury and the effect of variable temperatures on formation of its surface can be spoken of. It was predicted theoretically that the temperature is about $+340^{\circ}$ on the daytime side of the planet and $125-175^{\circ}$ below zero on the night-side.

(I note parenthetically, getting a little ahead of my story, that the theoreticians, as should have been expected, were in error: the measured temperature is between -185 and $+510^{\circ}$.)

The Jet Propulsion Laboratory geologists, Zohar and Goldstein, have been attempting for many years to carry out a radar analysis of the surface of Mercury. In 1970, not far from its equator, they succeeded in "smoothing out" something reminiscent of craters. The data of these studies are still being processed in Pasadena.

The first more than modest data on the surface structure of the first-born of the sun caused bitter disputes. T. MacCord and D. Adams, of the Massachusetts Institute of Technology, for example, state that the soil of Mercury is similar in composition to lunar soil, brandishing spectrograms with titanium and iron glass absorption bands. Robert Strom, of the University of Arizona, is convinced that "Mercury should differ completely from the moon in bulk composition."

The Soviet astronomer, Professor N. A. Kozyrev, introduced weighty evidence in favor of existence of an atmosphere. The director of the innerplanet section, English Astronomical Association, H. Robinson, declared in February 1974 that, "in all probability, Professor Kozyrev is correct." The scientific observer of the Associated Press, Nicolas Timmens, noted, with caustic, malicious joy: "The English astronomers consider that the Russian scientists have overtaken the American spacecraft and have made an important discovery connected with Mercury." And in general, he turned out to be right. On the night of 29-30 March of this year, Mariner-10 flew by Mercury, at a distance of 720 kilometers from the surface, and confirmed the observation of Kozyrev: Actually, the highly rarefied atmosphere of the tiny planet consists of inert gases and hydrogen. /216

The flight trajectory to Mercury was selected in such a manner, that the gravitational field of Venus turned the interplanetary spacecraft and headed it in the direction of Mercury. The maneuver was quite precise: an error near Venus of one kilometer in all (a vanishingly small quantity, if it is considered that earth and Venus were 45 million kilometers apart at this time) threatened to increase around Mercury to thousands of kilometers. Therefore, during the flight of Mariner-10, three trajectory corrections were provided for, by means of special engines, built by the Pasadena engineers.

Today, all the difficulties and anxieties are behind. Mariner transmitted more than 800 photographs to earth and . . . a quite dismal and, alas, familiar picture came to light before the eyes of the astronomers: craters, long, narrow valleys, mountain chains stretching out far from each other. At first glance, the "portraits" of Mercury were reminiscent of photographs of the moon. But only at first glance. There are no lunar "mare" on Mercury; there are vaster craters here, up to 300 kilometers across and up to 700 meters deep. There are few steep, sharp peaks here. Low mountains, up to a kilometer high, are characteristic of Mercury. The differences from the moon are supplemented by the fact that a very weak magnetic field has been successfully detected on Mercury, the shape of which is completely unlike the shape of the terrestrial magnetic field. Bruce Murray considers that, despite the outward similarity of the Mercury and moon landscapes, the evolution of these celestial bodies could have been different. In general, paraphrasing his words, spoken during our visit in California, Mercury also is like nothing else. Mercury is like Mercury.

Sweeping past Mercury, Mariner-10 became a satellite of the sun,⁶ and it will return periodically to the vicinity of Mercury. It is calculated that it will make such flybys in September 1974 and March 1975.

In Pasadena, Mariner-10 is considered to be primarily a Mercury explorer and Venus is a "bonus" for it.

"Venus interests those who are concerned with the atmosphere," noted Bruce Murray, "but Mercury is attracting geologists and geophysicists. Therefore, all of them were alarmed, when an orientation gyroscope broke down in the vicinity of Venus."

However, despite this failure and the breakdown of the solar plasma analyzer, Mariner-10 is considered in Pasadena to be the most nearly perfect unmanned spacecraft. Its radio wave spectrum for communication has been expanded, special television cameras have been installed and, finally, it is, if it can be said this way, much more "talkative." While the "Martian" Mariner-9 transmitted 16,000 bits of information per second, Mariner-10 can transmit 117,000.

It only remains to be added that modest people work at Pasadena. They emphasize especially that the credit for the launch of Mariner-10, which cost NASA \$114 million in all, does not only belong to them. Twenty-one universities of the U.S.A. worked in this program. More than 45 specialists assisted the Pasadena engineers in developing the equipment for this expedition to "meet the sun."

⁶The first artificial satellite of the sun was the Soviet unmanned spacecraft Luna-1, weighing (together with the last stage of the carrier rocket) 1472 kilograms, launched on 2 January 1959.

The flight of Mariner-10 undoubtedly is having an effect on preparation of future expeditions to the innerplanets. As in the case of Mars, the timetables of the planetary movements, which nature maintains with such accuracy that any timetable of preparation for a space launch can envy it, is of great importance in determination of the times of such flights. Summer 1978 is the most favorable for a flight to Venus. In Pasadena, work is already being carried on to build craft to be launched at this time, which could make a soft landing on its surface. Besides, the Jet Propulsion Laboratory has proposed to NASA that a new spacecraft, with the provisional name Voir, be launched in 1981, 1983, or 1984; it should become an artificial satellite of Venus and revolve around it in a circular orbit, passing above both of its poles, 500 kilometers from the surface. This would permit the spacecraft to carry out a radar survey of the /217 surface of Venus and to "inspect" objects down to tens or hundreds of meters in size.

As far as can be understood, Voir will not be simply a routine modernization of Mariner. The tasks en route which face this craft require considerably greater freedom of maneuver and this means considerably more powerful propulsion units and increases in fuel supplies. This alone must lead to re-examination of the Mariner design and to creation of a fundamentally new craft.

However, I will not make any guesses. The most embarrassing positions of futurologists involve predictions of scientific discoveries. And this is not so important, when these discoveries are going to occur in 1978 or 1981. For many centuries, astronomers have designated Venus by a symbolic emblem, a round mirror on a long handle. You see, Venus is the goddess of beauty and beauty is imperishable. And what are three or four more years for it?!

5

The gray cloudcaps of poles gradually change into light blue bands, and then come yellow, orange, reddish-brown, like brick dust. Bright concentric hoops girded the entire atmosphere of the giant planet. The famous "red spot," over the secret of which astronomers of the entire world have been racking their brains for so many decades, burned bright on a silver-gray background. Another white, oval spot cut into the brick-red haze, like the cap of a terrestrial tropical hurricane, if it is looked at from orbit. But what is this about a hurricane, when the size of the white spot is 16,000 kilometers! Sometimes, some white lines were highly visible, as if a clumsy retoucher had underlined this fantastic picture. And all this floated and spun like a top, a strange, mottled top, in the black abyss of the sky . . .

This was the picture the specialists at Pasadena saw at five hours twenty-four minutes in the morning Moscow time, 4 December 1973,

when the Pioneer-10 spacecraft reached its desired goal, flying past Jupiter at a distance of 130,000 kilometers. The journey, lasting 21 months, marked a new stage in study of the solar system: flights, not to neighbors in space, but to the remote giant planets and further, to the edges of outer space.

Despite the fact that Jupiter has been known better to astronomers on earth than Venus or Mercury, the first flight told a great deal of interest about this largest planet in the solar family. The Pioneer data shattered many predictions of the theoreticians into smithereens. It turned out, for example, that the magnetic field of Jupiter occupies a region twice as large as was thought, and that it has more complicated structure than the magnetic field of earth. The radiation intensity in the radiation belts of the planet is a thousand times that of earth, but the calculations of the theoreticians show that it should have been a million times greater. Nevertheless, the total radiation dose received by Pioneer was a thousand times the lethal dose for man. Pioneer-10 determined that the daytime and nighttime temperatures of Jupiter remain approximately constant, at about -133°C . It is evident that the thick atmosphere, rotating rapidly together with the planet (a day on Jupiter is about ten hours), assists in heat transfer.

During the flight past the planet, Pioneer-10 transmitted 340 color images of Jupiter, which are now being analyzed. It is conjectured that the famous "red spot," the color of which changes in 30-year cycles, from red to light pink (and, sometimes, it is not visible at all), is none other than an ascending column of gases (volcano?). Pioneer-10 discerned, moreover, an obscure projection at one end of the spot, which is not seen from earth.

It also successfully photographed four of the twelve satellites of Jupiter: Io, Europa, Ganymede and Callisto. They noted with a smile in Pasadena that Ganymede resembles a "flying saucer" above Jupiter. Many of these satellites of the huge planet are of still greater interest in what recent spectrographic analysis has shown: Ganymede and Europa (and, with less likelihood, Callisto and Io) are covered with formations resembling ice. Water is a companion of life. Hypotheses on the possibility of its existence in the region of the giant planet, in this manner, have received support.

Is life possible on Jupiter itself? It would appear that the /218 alkaline atmosphere of the planet would be intolerable to a living creature. However, at the end of last year, NASA biologists discovered bacteria in an underground California source, saturated with alkali. They moved, grew and reproduced in a sodium hydroxide solution.

A more likely location of life is Titan, the largest satellite of Saturn, approaching Mercury in size. It has turned out that Titan has an atmosphere, evidently sufficiently thick to conserve the heat coming from its interior. The temperature of the "large moon of Saturn" has turned out to be tremendously higher than was thought. It reaches 38 degrees.

"Titan resembles a 'time machine' in a way," says Carl Sagan. "It assists people to return to millions of years ago, in the time when life had just been born on earth. I do not think that primary forms of life are completely excluded on Titan . . ."

One can scarcely succeed in traveling rapidly in the "time machine," of which the American astronomer speaks, although we have a right to expect the most improbable discoveries from the first explorers of the remote worlds. Following Pioneer-10, its twin, Pioneer-11, was launched on 5 April 1973. It is executing a maneuver rather resembling the flight of Mariner-10 to Mercury. During the approach to Jupiter on 5 December of this year, the gravitational field of this planet should "bend" the trajectory of Pioneer-11 and direct it towards Saturn. According to ballistics calculations, it should approach Saturn in October 1979.

Space technology has already solidly become a part of our consciousness, as a technology of superhigh velocities and, obviously, the times mentioned cause bewilderment and irritation. Alas, when the talk turns on space distances, some psychological readjustment is necessary. The human imagination, with all the fantastic diversity of its capabilities, is helpless in the world of those quantitative relationships, which man has not encountered in daily life. We clearly imagine a thousand. A thousand people, books or rubles. But no normal man can imagine a hundred million, just as he cannot imagine real distances, even in such an extremely limited region of space as the solar system. If I simply state the distance from the earth to the giant planets in millions of kilometers, these figures generally tell you little. A visible comparison is needed. To assist in the comparison, we use simple, well-known distances. Say that the sun is in Moscow and earth in Ryazan. How will the solar system seem then? The orbit of Mercury passes by Volokolamsk and, of Venus, by Kalinin. Mars turns out to be in Smolensk, Jupiter in Perm, Saturn beyond Ufa, Uranus further than Krasnoyarsk, Neptune, somewhere in the Chitinsk district and Pluto, in Vladivostok. These calculations are approximate, but sufficiently precise to give a general idea of the relative distances between the planets. It is clear to everyone, that a journey from Ryazan to Kalinin is one thing, and, to Eastern Siberia, quite another thing.

For a flight to remote worlds, not only is a more powerful rocket required, the acceleration of which overcomes solar gravity and not only more nearly perfect procedures for calculating distant trajectories. A number of fundamentally new obstacles arise. In the flight to Mars, designers have to reject control of such a flight from earth, since the earth-craft-earth radio signal transmission time excludes the possibility of any operational intervention in operation of the control system. The necessity for an onboard computer-commander becomes completely obvious, if it is considered that a signal from Jupiter goes to earth in 46 minutes and from Saturn, in about 80 minutes. However, the matter is not that the signal takes a long time, but that the gigantic distances "wash out" this signal, make it so weak, that the most sensitive of

"radio ears" of earth do not hear it. It was calculated in Pasadena that, in Jupiter orbit, the power of the Pioneer-10 signal reaching earth is one quadrillionth of a watt. The imagination reels at this figure. Let us assist it. If the energy of this signal were stored from the time when dinosaurs lived on the earth, there would be enough of it today to light a 100-watt lamp for one thousandth of a second. The human eye would not catch the instant when the lamp flashed.

The builders of the Pioneer truly had to break through an awful/219 power cycle. On the one hand, the further from the sun (and, consequently, from earth) the spacecraft flies, the more powerful its radio transmitting equipment has to be. But, the further it flies, the less energy its solar batteries receive from the sun. For purely technical considerations, their surfaces could not be increased to infinity. It turned out that solar batteries were incapable of replacing the energy consumption in flights to the giant planets. Therefore, they were replaced in Pioneer-10 by four radioisotope thermoelectric generators, operating on plutonium-238 dioxide. In the opinion of specialists, they will provide more than 100 watts of energy for a period of five years, i.e., until 1977, although it is hoped in Pasadena that Pioneer-10 will be heard until approximately 1979, despite the decrease in power.

And then? It still will speak, tell about interplanetary space and cosmic rays, but we will not hear it. The energy of the isotope sources will run low, and Pioneer will not be able to call to us; it will whisper more and more softly, as though falling asleep, and it will then fall silent forever. A tiny bit of earth, once warmed by the heat of human hands soaking up labor and knowledge, cools down and dies, but it will fly further and further. It will intercept the orbit of Pluto after 15 years and begin its great voyage in the endless interstellar ocean. Its route is toward the constellation Taurus, which it will reach in 11 million years . . .

Camille Flammarion, an astronomer with the soul of a poet, lived in France a hundred years ago. He wrote the prophetic words: "The day is coming, and it is already close, since you are fated to see it, when study of the conditions of life in various regions of the universe will be the main task and greatest fascination of astronomy. The time is coming soon, when, instead of being occupied simply with calculation of distances and motion and determination of the physical composition of neighboring planets, astronomers will study their physical composition, their geography, their climatology and meteorology, penetrate the secrets of their organization of life and will discuss the question of their inhabitants."

And now, this day has come. An authentic revolution in astronomy is happening before our eyes, in the ancient science of the earth. Man has long considered the remote worlds, but now he is stretching out his hands to them, in order to harvest the fruit from the tree of knowledge.

We stand today on the threshold of the secrets of the unforeseeable, lying beyond the limits of our imaginations. We are ready to start on journeys, perhaps the most dangerous and difficult, in order to return with unprecedented treasures of knowledge. These treasures will not only increase our strength in battles with nature, they certainly cultivate pride and nobility and still greater love for our native planet in the people of earth, and still greater, truly human regard for everything in it. Space forces us to pay for this tremendous work, it requires infinite efforts and resources, strikes our hearts with pain for the irretrievable losses, but, beyond all this, it rewards man without fail, with that which makes him more human.

The fate of discovery of the remote planets is being decided on earth. Here, the times of future launches are determined. Here, the launch pads are selected. The engineers will argue over which launch complex is more nearly perfect. However, surely, they all agree with the fact that any launch is possible, under one obligatory condition, peace.

On 24 May 1972, during the stay of the President of the U.S.A., R. Nixon, in Moscow, an agreement on cooperation in space research was signed. In NASA, this day truly is called a "turning point in international space cooperation."

During his historical visit to the United States, the General Secretary of the Central Committee of the Communist Party of the Soviet Union, L. I. Brezhnev, at a reception in Casa Pacifica, expressed the hope for successful collaboration of Soviet and American astronauts in the great matter of revealing the secrets of the universe.

The year 1975 is at hand, the year of the first joint international space flight in history. I want to hope that, in the experimental Soyuz-Apollo project, interesting extensions will arise, that the cooperation of scientists of USSR and the U.S.A. in the area of study of the planets of the solar system and of the nature of space will develop further in the interest of peace, science and the progress of mankind.

. . . after 11 million years, Pioneer-10 will arrive in the constellation Taurus. Who knows, perhaps, at this inaccessibly distant time for earth, the minute will come, when other beings, not similar to us, but endowed with intelligence, will meet this tiny, already long-dead spacecraft. Yes, the probability is insignificant, but who knows . . . therefore, in any case, the engineers from Pasadena fastened a small anodized gold plate to Pioneer, which, as they say, may stand the severest test of time. If those who find it are familiar with the structure of the hydrogen atom, nuclear decay and the solar planetary family, they will learn, from where and when the space wanderer came to them. And they must without fail know who sent it: two figures, a man and a woman, are represented in this letter to the stars. The right hand of the man is raised and turned

with the open palm forward, symbolizing greetings, welcome and peace by this gesture.

We lack all of this most often on earth, but, nevertheless, we are glad that precisely these symbols of people have been sent into endless space. It is hoped that somebody, sometime will read this letter to the stars and know that we exist. But it is hoped still more that people themselves will not forget its message, so that sound intelligence and eternal peace will finally triumph on this small, but beautiful planet.